Space VLBI Project VSOP

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Abstract

A space VLBI satellite is planned to be launched in 1995 by the Institute of Space and Astronautical Science (ISAS), Japan. The satellite is the main element of the VLBI Space Observatory Program (VSOP), which is a worldwide collaborative project involving satellite operations, link stations, and ground radio telescopes. The basic parameters and management plan of VSOP project are reviewed.

1. Introduction

The VLBI Space Observatory Program (VSOP) was initiated as a cooperative project between the Institute of Space and Astronautical Science (ISAS) and the Nobeyama Radio Observatory (NRO), Japan, in the late 1980's. The VSOP satellite has an 8-m deployable radio telescope and three radio astronomy receivers, and will be launched in 1995. It is expected to have a lifetime of more than three years. As the VSOP is a space VLBI imaging mission, the worldwide support of link stations and ground observing telescopes is needed. Some detailed descriptions are in the proceedings of the International VSOP Symposium (1992).

2. Orbit

The orbit of the VSOP satellite is elongated (See Table 1) and precesses so that good UV coverage is expected over a wide area of the sky. As the orbit is not synchronous, about 6 hours per orbit, the UV coverage evolves day by day. Since the apogee is not very high, VSOP is good for imaging rather than high resolution. There are, however, several constraints on the satellite. For instance, low declination sources may not have good UV coverage due to the avoidance angle from the Sun. The final situation will depend on the exact time of the launch.

Table 1. Orbit Parameters

Apogee Height	20,000 km
Perigee Height	1,000 km
Period	$\sim$ 6 hrs
Inclination	$\sim 31°$

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3. Radio Telescope

The main reflector is hexagonal in shape. Its surface is shaped by a tension truss structure of cable nets, and six extendible masts which tension the surface. The accuracy of the mesh surface is 0.5 mm rms. The aperture is 50 m^2 and the aperture efficiency is 40%, 56%, and 44% at 1.6, 5, and 22 GHz, respectively.

4. Receivers

The VSOP satellite has three receivers at 1.6, 5, and 22 GHz with uncooled front-ends and left-hand circular polarization feeds. Table 2 summarizes the receiver and system temperatures for each frequency, together with frequency coverage. Two IF channels with 16- or 32-MHz bandwidth are available so that simultaneous observations in any two of the three frequency bands, or at two frequencies within any one band, can be made (See Table 3). The observing frequencies can be set independently for the two channels in 1 MHz steps. The sensitivity (5ΔS) with a VLBA telescope at 5 GHz (T_{sys} = 230 Jy) is, for example, 190 mJy with 32-MHz bandwidth and 2 minutes integration.

Table 2. Receiver and System Temperatures

Band	1.6 GHz	5 GHz	22 GHz
Frequency	1.60-1.73 GHz	4.70-5.00 GHz	21.9-22.3 GHz
T_{RX}	30 K	50 K	150 K
T_{sys}	100 K	120 K	200 K
T_{sys}	14,000 Jy	12,000 Jy	25,000 Jy

5. Link and Observing Mode

The received signal is sampled and sent to the link stations at 128 Mbps at 15 GHz. Each link station also sends a frequency reference signal from its hydrogen maser. A round-trip phase link signal is used to measure the error of the phase transfer. As the uplink and downlink frequencies are high and are very close to each other, the phase fluctuations caused by ionospheric disturbances are greatly reduced.

As a recorder is not installed on board, link stations will have VLBI terminals to record the VSOP satellite data. Consequently, a number of link stations, which are effectively distributed around the world and ground observing telescopes, are needed to get good UV coverage. Five link stations are now planned at Usuda in Japan, Goldstone and Green Bank in the US, Canberra in Australia, and Madrid in Spain.

VSOP observations will have three data parameters: the number of sampling bits, the number of IF channels, and their bandwidths. However, these are not mutually independent and should be chosen so that the total bit rate is 128 Mbps. In Table 3, the available combinations are listed.

Table 3. Observing Modes

Bandwidth	bit	Channel
16 MHz	2	2
32 MHz	1	2
32 MHz	2	1

6. Recorders and correlators

At Usuda link station, a K4 recording terminal is installed which is capable of recording the 32-MHz modes; VLBA recorders will be installed in the other stations. The K4 tapes will be correlated with the VSOP correlator which is planned to be built in Japan. This correlator is designed to cover items special to space VLBI, in particular, having a very wide fringe search window. At the VSOP correlator facility, data translation systems from VLBA to K4, and from S2 to K4 will be installed, to handle all types of recording systems. The S2 system has been developed in Canada and is used in Australia. VLBA tapes will also be correlated using the VLBA correlator.

7. Management

The VSOP International Science Council (VISC) has been established, and will manage all scientific issues relating to VSOP observations. The Announcement of Opportunity (AO) will be released 1.5 years ahead of the launch of the VSOP satellite, and proposals will be screened by peer review. Participation of the ground VLBI networks and telescopes is being negotiated, and a certain amount of their observing time will be devoted to VSOP. The Global VLBI Working Group has been acting as an interface between VSOP and ground networks/telescopes.

References

[1] *Frontiers of VLBI.*,1992, Proceedings of the International VSOP Symposium and of the mm-VLBI Workshop, eds. H. Hirabayashi, M. Inoue and H. Kobayashi, Universal Academy Press, Inc., Hongo, Tokyo, Japan.